Terrain Analysis Support: Mobility Modeling for Peace-keeping Operations

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Purpose:

As part of a ‘terrain analysis concept’, to derive landforms and their associated soils from satellite imagery (and derived image products), to provide a key input to trafficability models for production of on/off-road mobility maps for use by UN Peace-keeping forces.

- Interpret landform features from various readily available satellite imagery;
- Characterise imagery in terms of landform-soil relationships;
- Define landform-soil terrain units as key input to trafficability models;
- Develop re-usable methodology for terrain analysis for trafficability;
- Develop complementary 'interpretation keys' for future trafficability projects.
Trafficability? What is mobility modelling?

• Trafficability = ability of a given vehicle to traverse a specified terrain (on-road and off-road)
• Trafficability analysis helps tactical decision makers determine likely avenues of approach, plan logistical operations, and plan movement of peace-keeping forces resources + vehicles
• Tactical importance of accessing accurate information on trafficability has led to the development of mobility modelling (largely progressed by Military organisations such as the US Army Corps of Engineers)
• Mobility models attempt to model the complex interaction of key elements, including terrain (slope/aspect, soils, barriers to movement/obstacles), vegetation, land-use, vehicle characteristics and weather
Trafficicability? What is mobility modelling?

**Nato Reference Mobility Model (NRMM)**

- NRMM is a comprehensive analytical model designed to evaluate objectively the on- and off-road mobility of vehicles by means of digital computer simulation.
- Evolved into Condensed Army Mobility Model System (CAMMS), with addition of custom map display capabilities.
- NRMM II released in 1992, with ability to utilise the Unified Soil Classification System (USCS) for modeling soil performance.
- National Geospatial Intelligence Agency (NGA) of the US Government commissioned ESRI and other key partners to develop Commercial Joint Mapping Toolkit (CJMTK), which included an ArcGIS implementation of NRMMII as an enhanced mobility component (provides mobility modeling and mapping capability within ArcGIS).
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Study Area

Located in the Northern state (Shamal Darfur) of the Darfur region of Sudan, 11 km due west of the state capital, Al-Fasher. Area is located mostly within the El Fasher province and includes the city of Tawila, as well as the adjacent Internally Displaced People (IDP) camp. Area > 2245 km², with a perimeter in excess of 217 km.

Area corresponds exactly to 3 adjacent TLM50 (Topographic Line Map 1:50,000 scale) map sheets - provides a degree of integration, as well as ensuring a common geography, with the ongoing Darfur Mapping project to provide TLM50 coverage of Darfur in support of UNAMID.
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Methodology – Image Processing

Image Preparation

Landsat ETM (30m res, 7 bands)

SPOT 5 (2.5m res, 3 bands)

ASTER (15m res, 9 bands)

Radiometric Correction & Destriping

Conversion to Radiance

Layer Stack (9 bands)

Geometric Correction

Mosaic and subset to Study Area

ETM Mosaic

SPOT Mosaic

ASTER Mosaic
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Methodology – Image Processing

Spatial Enhancement

Resolution Merge
SPOT with Landsat (2.5m res 7 bands)
SPOT with ASTER (2.5m res 9 bands)
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Methodology – Image Processing

Spectral Enhancement

Decorrelation Stretch
- Spot/Landsat merge
- Spot/Aster merge

Principal Components Analysis
- Landsat PCA
- ASTER PCA

Band Ratios (Mineral & Vegetation Indices)
- Clay Mineral Index
- Fe²O³ Index
- NDVI
- Composite Mineral Index
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Methodology – Image Processing & GIS Analysis

Topographic Analysis and 3D Visualisation

- SRTM Digital Elevation Model
- Surface Analysis
  - Slope
  - Hillshade
- 3D Visualisation
  - Analglyphs
  - UN Earth
  - ArcScene
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Methodology – Image Processing & GIS Analysis

Interpretation & Feature Extraction

- Manual Feature Extraction (Interpreter-based)
  - Interpretation of Terrain Units, Landforms & Soils

- Basic Land Unit Geodatabase
  - BasicLandUnit.mdb
    - ALLGranTerrain
    - AmphSedimentTerrain
    - FoldSedimentTerrain
    - GranSchistTerrain
    - MicaSlateTerrain
    - MicaShaleTerrain
    - QuartziteTerrain
    - QuaternaryTerrain
    - SoilProfile
    - VolcanicTerrain

- Landform Area Geodatabase
  - DarfurPhysiography.mdb
    - Landform
      - LandformA_Chem_Mech
      - LandformA_Depo_Aeol
      - LandformA_Depo_Flu
      - LandformA_Eros_Aeol
      - LandformA_Eros_Flu
      - LandformA_Structural
      - LandformA_Volc
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Methodology – Image Processing & GIS Analysis
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Methodology – Image Processing & GIS Data Processing

Data Preparation for Mobility Model

Darfur Mapping Project (Vmap2 TLM50s)
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Methodology – Image Processing & GIS Data Processing

Data Preparation for Mobility Model

Landform Area Geodatabase

UN Geotechnical Soils Maps (Interim Product)
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Methodology – GIS Data Processing

Data Input for Mobility Model

Enhanced Mobility Component of CJMTK

Trafficability Modelling (NRMM II)

Ongoing Process

Trafficability Maps
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Outputs (so far…)

1. Geotechnical Soil Maps
   • Potential use in engineering, de-mining, etc

2. Interpretation Keys
   • To assist with recognition and extraction of landforms and their associated USCS soil types

3. Evolved methodology for creating input data for mobility modelling
   • Slope
   • Soils
   • Obstacles
   • Vegetation
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What next?

1. Implement and test NRMM II for ArcGIS
   - Dlls and code for enhanced mobility component of CJMTK received from US Army Geospatial Centre (AGC)

2. Develop GUI for ArcMap

3. Compare outputs from NRMM II and standard mobility model from BTRA (Battlespace Terrain Reasoning & Awareness) – simplified model based on NRMM II currently in development at AGC

4. Develop extraction guide for mobility-related feature classes in VITD
Questions?